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THE CAMPHOR THRIPS.[1]

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INTRODUCTION.

Many years ago camphor trees, *Cinnamomum camphora* (L.) Nees & Eberm., were introduced into Florida for ornamental uses. The beauty and grace of the tree made it very popular for the beautification of grounds, roadways, and borders of groves. The ease with which this tree was propagated and the luxuriousness of its growth (fig. 1) led to the belief that it could be grown in large acreages to obtain a commercial supply of camphor.

The first attempt to produce camphor gum under commercial conditions was made at Satsuma, Fla., in 1903. The total investment on this plantation amounted to nearly one million dollars and during the period of the existence of the plantation (1903–1921), 1,800 acres were set to camphor trees. Another plantation, consisting of 2,200 acres of camphor trees, was located at Waller, Fla., midway between Stark and Green Cove Springs, and represented an investment of over a million dollars. It was thought that by using machinery on an extensive scale camphor gum could be produced as economically here as in the Oriental countries, where the cost of labor is low. Practically all of the work of planting the trees, cultivating, harvesting the branches for distillation, and producing the camphor gum itself was done by mechanical means.

[1] *Cryptothrips floridensis* Watson; family Phloeothripidae, order Thysanoptera.

[2] The present investigations were begun by C. A. Weigel, of the Bureau of Entomology, assisted by C. A. Bennett, who conducted a large part of the field work during the first year. Practically all the biological work was done at Orlando, Fla., by the junior writer, together with observations made at the camphor farm at Satsuma, Fla. The control work was done mostly on the camphor plantation at Satsuma, and in addition pruning and spraying experiments were carried on at Orlando. Similar life-history work was carried on at Gainesville, Fla., by Prof. J. R. Watson, to whom credit is given for certain notes and valuable assistance. The writers desire also to express their appreciation to C. W. Loveland, manager of the camphor plantation at Satsuma throughout the period of the investigations, who extended to them many courtesies as well as material aid during the progress of the work.

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Many obstacles to the production of camphor in commercial quantities at a reasonable price were soon encountered, the most serious of which was the injurious effect on the trees of the usual method of pruning or harvesting the branches. The practice was to cut the

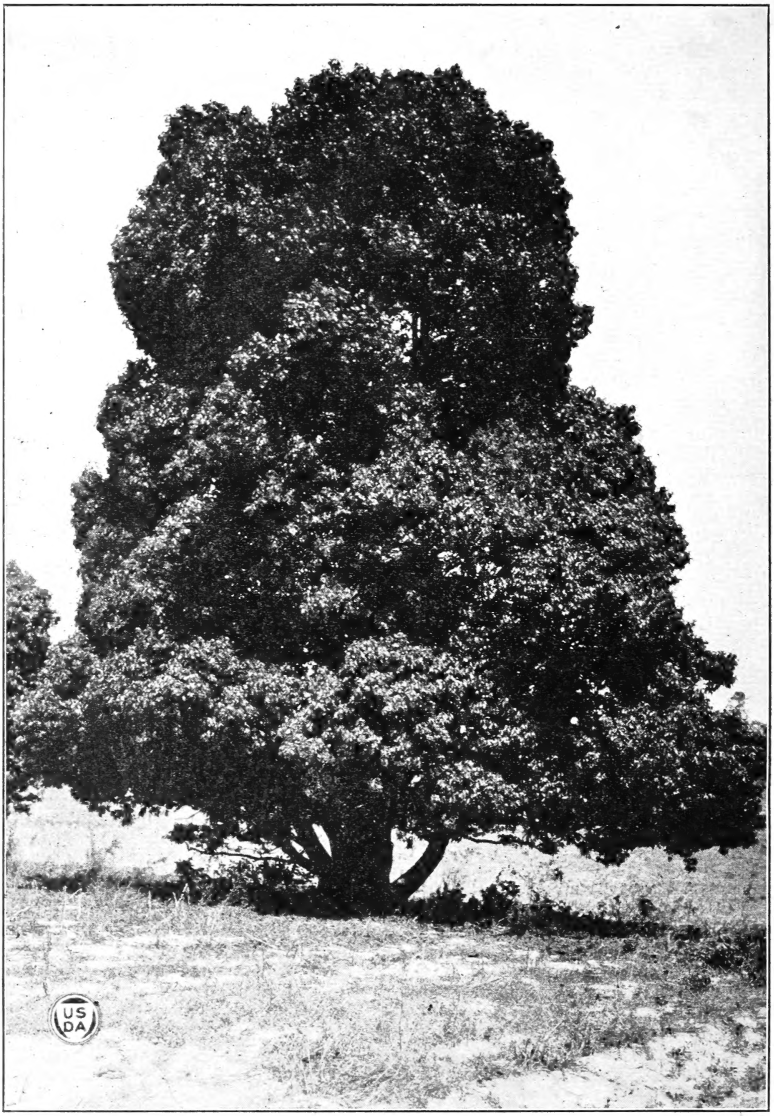

FIG. 1.—Camphor tree showing characteristic habit of growth.

branches from the top and sides of the tree each year, the cuts being made without regard to the nodes. In many instances this left from 1 to 12 inches of the branch extending beyond the node. Since camphor trees, except in rare cases, do not put out new branches

between the nodes, the cut end invariably died back to the node. In these dead ends injurious fungi and borers developed and often their effect extended beyond the node.

Plants thus treated are always stimulated to new growth. When this occurred in late fall or winter the trees were not able to resist low temperatures which an unpruned tree could withstand without the slightest damage. The combined effect of the method of pruning and the injury from cold was a great set-back to the growth of the trees, resulting in the dying back of many large limbs and in some cases the death of the trees.

The camphor thrips was a third obstacle to camphor production. This pest appeared in great numbers on the cut ends and on the new shoots that follow pruning. This new growth appeared to furnish an unlimited food supply for the thrips, which multiplied without any apparent restriction. The effects of the thrips on trees thus pruned was very marked. Plate IV, B, shows a tree attacked by the thrips, following the usual pruning, resulting in the death of many of the limbs.

To discover means of controlling this pest, preliminary investigational work was carried on by Prof. J. R. Watson (*3, 6*),[3] Florida Agricultural Experiment Station, Gainesville, Fla. This work showed that the insect was spread over the entire plantation at Satsuma, Fla., and also indicated that it would be a difficult and expensive pest to control by any artificial means. The seriousness of the situation led Congress to appropriate funds with which to work out some economical method for the commercial control of this pest. The work began as a special project of the Bureau of Entomology, with Professor Watson cooperating. After about a year the project was placed under the Tropical and Subtropical Fruit Insect Investigations, where it was continued over a period of two more years.

HISTORY AND DISTRIBUTION.

The camphor thrips was first discovered at Satsuma, Fla., in November, 1912, by William O. Richtman (*8*), who found the pest spread over the entire plantation and was very much alarmed by its apparent ravages. It has since been found in many parts of Florida, including Orlando, Clearwater, Oneco, Sebring, Daytona, Fort Pierce, and Glen St. Mary, and no doubt may be found in all locations about these places. In fact its range is now known to cover all of Florida except the extreme southern part. Search has been made for it in Dade County but without success, though very few camphor trees are grown in that part of the State. The thrips also occurs on camphor trees in Alabama, Mississippi, and Louisiana, and probably in Georgia, since it has been found close to the Florida-Georgia State line. In all probability the camphor thrips will be found throughout the range of the camphor trees. Camphor trees grown as ornamentals will probably not suffer to any serious extent from the ravages of this pest, but it is quite certain that in hedges which are pruned back at frequent intervals camphor will be severely damaged by the thrips, a fact which may necessitate the abandonment of camphor for ornamental hedges.

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[3] Figures in parenthesis (italics) refer to "Literature cited," p. 29.

ORIGIN.

The original theory of Watson (*5*) regarding the origin of the camphor thrips was that it had been introduced into Florida on nursery stock from the Orient and was therefore peculiar to the camphor. Since camphor trees are not indigenous to the United States, this seemed to be a reasonable explanation. Later investigations, however, tended to show that the thrips might be a native insect and had taken to the camphors because of their close relationship to its natural hosts. Watson (*11*) states that the bay trees of the genus Persea (Tamala) are the natural hosts of the camphor thrips. He found a thrips on the bays which was very similar to *Cryptothrips floridensis* and concluded therefore that these were the camphor thrips in their native habitat. Careful and extended investigations by the junior author, however, have shown this bay thrips to be a new, although closely related species. It was therefore described (*12*) as *Cryptothrips laureli* n. sp. Because of the close similarity of the adults in the two species, as well as the relationship of their hosts, it was reasonable to believe from a superficial examination that they might be the same species. There are, however, some distinguishing structural characters which were revealed after a study of the immature forms and habits had shown them to be distinct from the camphor thrips.

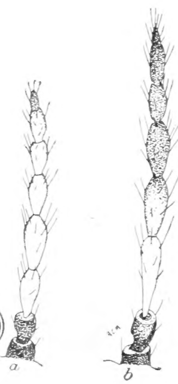


FIG. 2.—Structural characters of antennæ of the camphor thrips and the bay thrips: *a*, Antenna of camphor thrips; *b*, antenna of bay thrips. Enlarged.

COMPARISON OF BAY THRIPS AND CAMPHOR THRIPS.

The camphor thrips is fully described in later pages. The bay thrips differs from it in the following structural characters: Larger size; antennæ longer and darker colored and with the third segment especially larger and more slender in shape (fig. 2); stronger spines on the head and thorax and a much smaller number of doubled hairs on the fringe of the fore wings. The eggs are larger also than the eggs of the camphor thrips, are light straw-yellow instead of black, becoming red during the development of the embryo, and are covered with irregular scale-like patches rather than the regular hexagonal pattern (fig. 5) of the camphor thrips. The distinguishing character of the larva and the pupa is the bright and conspicuous carmine red color compared with the dull orange red of the camphor thrips. The time required for development is also longer in all stages. In the adult stage different feeding habits are found, and usually sexual reproduction instead of parthenogenesis.

The food preferences of these two thrips are also different. Although the bay thrips can be made to live on camphor, no instances have ever been found in which it had taken to the camphors naturally. Its natural hosts include only the four species of Persea which are native of Florida (*4*). On the other hand, the camphor thrips will live on camphor only and could not be made to live on bay, as will be shown in detail later. Several generations of the bay thrips

reared on camphor in cages did not change their appearance or habits in any way. The conclusion may therefore be drawn that the camphor thrips has originated from another source. Since it does not occur on any of the native trees of the family Lauraceae, it, in all probablilty, must be an introduced species. No evidence, however, has been obtained of its presence in any of the countries where camphor trees are indigenous. The specimens received by Watson from Ceylon and reported (*5*) as *Cryptothrips floridensis* have since been determined as a different species.

NATURE AND EXTENT OF INJURY.

The injury from the camphor thrips seems to be confined almost entirely to pruned trees or trees previously injured from other causes.

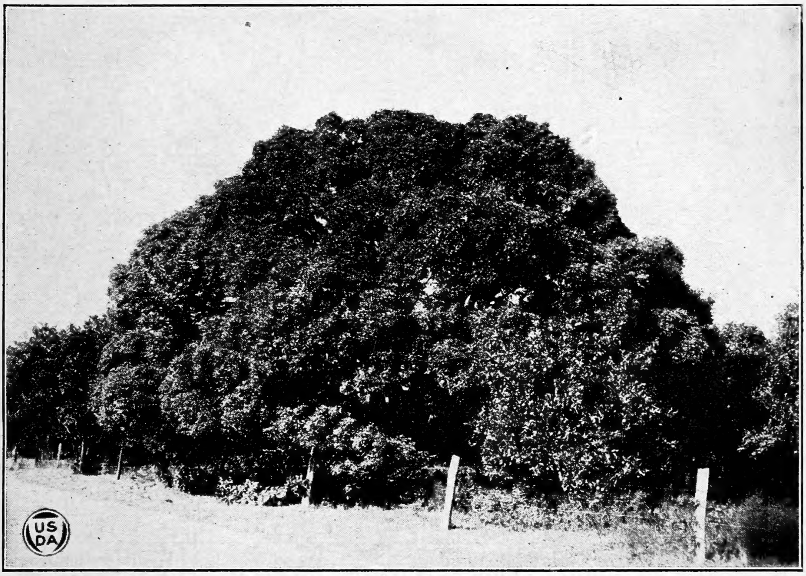


FIG. 3.—A 40-year-old camphor tree, showing magnificent size which these trees can attain when uninjured by pruning or thrips.

When grown as an ornamental or shade tree and not cut back, the camphor tree is very luxuriant and often attains great size. While the thrips can often be found on such trees, they have never been seen in large numbers or been known to do any appreciable damage to such trees. Many beautiful specimens of the camphor tree can be found over the State in regions where thrips occur and are even abundant on pruned trees. The tree illustrated in Figure 1 is growing on the camphor farm at Satsuma near the fields in which the thrips have been most injurious. Figure 3 illustrates one of the largest camphor trees in the State. This tree, planted in 1880, now has a circumference of 16 feet 3 inches, with an average spread of 60 feet and a height also of 60 feet. Throughout its growth it has been comparatively free from any pests which have unduly interfered with its development. Camphor trees have also proved valuable as windbreaks for citrus groves and when planted as hedges and allowed

to grow unhindered they attain great size and become remarkably beautiful (fig. 4).

When grown for ornamental hedges along streets or in dooryards, however, where it is necessary to keep the trees pruned back regularly, they suffer considerable damage from the thrips. They suffer also when the trees are cut back to procure material for distillation. The insects collect in great numbers around the cut ends and feed upon the plant tissues. In addition they destroy the buds (Pl. II) and new growth when put forth by the trees, and even work in the limbs (Pl. III), causing the bark to crack (Pl. IV, A) and later the limbs to become deformed (Pl. V). Their chief damage is probably to the buds, and when present in any great number they prevent the trees from putting forth very much new growth, without which

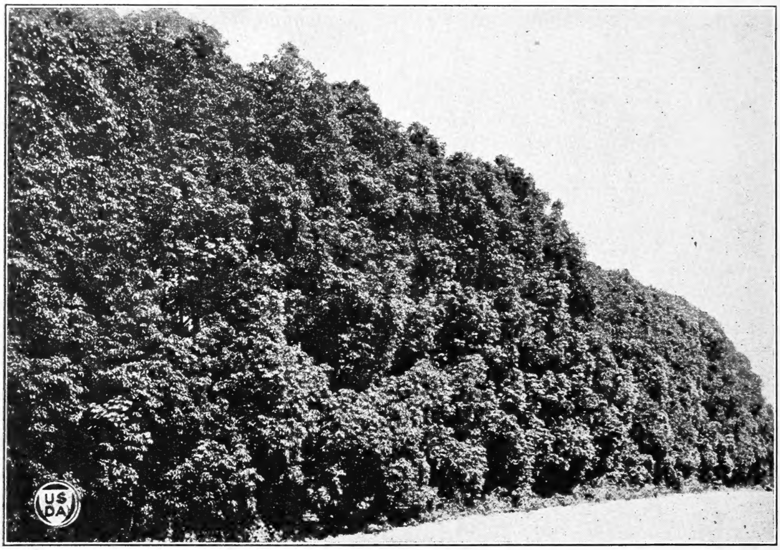


FIG. 4.—Row of camphor trees planted as a windbreak for a citrus grove. When uninjured the trees make a beautiful hedge and are not seriously attacked by the camphor thrips.

camphor production is cut off. As will be shown later, the usual pruning practices had to be changed. Instead of pruning the trees promiscuously and cutting the limbs back to stubs it was found necessary to cut the trees off at the level of the ground.

DESCRIPTION.

ADULT.

The original description of the adult (Pl. I, A) was by Prof. J. R. Watson (*1*), as follows:

Cryptothrips floridensis, new species.

Measurements: Head, length 0.25 mm., width 0.20 mm.; prothorax, length 0.17 mm., width 0.34 mm.; mesothorax, width 0.40 mm.; abdomen, width 0.44 mm.; total length of insect, exclusive of antennae, 1.89 mm.; tube, length 0.14 mm., width at base 0.075 mm.; antennae, 1, 36 μ; 2, 51.7 μ; 3, 77.6 μ; 4, 78 μ; 5, 65 μ; 6, 63 μ; 7, 54.5 μ; 8, 40 μ; total 0.42 mm.

General color, black, no purple pigment; tarsi dark brown and antennae yellow.

Head, cylindrical, one and one-fourth times as long as wide; sides almost straight and parallel.

Eyes somewhat triangular, $9 \times 6\ \mu$, reddish brown, not pilose, about 250 facets.

Ocelli present, concolorous with the eyes to which the posterior ones are closely applied.

Mouth-cone, rather bluntly rounding, reaching three-fourths of the way across the pronotum.

Antennae with eight segments, one and two-thirds times as long as the head; segments one and two black, concolorous with the head, segments three to six clear yellow, eighth and tip of seventh yellowish-brown.

Prothorax short, a little shorter than the width of the head, triangular, narrow in front, well-developed spines on posterior angles and two on the anterior part of each lateral margin.

Mesothorax wider than the prothorax and very short, sides almost straight.

Pterothorax a little narrower than the abdomen, sides almost straight.

Legs long, concolorous with the body except the brown tarsi.

Wings: Fore-wings reaching almost to the end of the abdomen, fringed with hairs which are nearly as long as the width of the abdomen, doubled for from 15 to 19 hairs, nerve weak and short, constriction rather slight.

Abdomen usually long and slender, usually widest at the second or third segment and tapering gradually to the seventh from which it rounds off more abruptly. A pair of bluntly-tipped hairs along the margin of each segment, becoming longer and arising from nearer the posterior angle on the posterior segments. The tube is 0.14 mm. long and about 0.075 mm. wide at the base. The end bears a circle of stiff hairs, eight of which are about two-thirds as long as the tube, six are shorter and weaker.

Males are similar but smaller.

FIG. 5.—Eggs of the camphor thrips. Greatly enlarged.

EGG.

The following description of the egg and those of the larval stages are original.

The eggs (Pl. I, B; fig. 5) average about 0.37 by 0.15 mm. in size and are dull black throughout the life of the egg. The entire surface is reticulated, being covered with a network of waxy material arranged regularly and giving the shell the appearance of being divided into hexagonal plates.

FIRST-STAGE LARVA.

When first hatched, the young larvæ (Pl. I, C) are a light straw color and fusiform, the legs and antennæ being disproportionately large and giving the insects an ungainly appearance. The average length is nearly 1 mm. and the width of mesothorax about 0.17 mm. The eyes are dark brown and the head, antennæ, legs, and the last two abdominal segments are light brown. The thorax contains two light-brown spots so large as almost to cover it and make it appear brown with a yellow stripe through the center. On the dorsal surface of each abdominal segment is a row of six brown dots from which arise short colorless hairs. These dots are so arranged as to form six longitudinal rows along the entire length of the abdomen.

SECOND-STAGE LARVA.

Average measurements of the second-stage larvæ (Pl. I, D) when full grown are: Length 2.29 mm.; width of mesothorax 0.547 mm. General color orange red. The body is a light yellow to whitish color, but appears orange red owing to the presence of numerous very small, irregularly shaped blotches of orange-red pigment underneath the epidermis. The antennæ, legs, and last two abdominal segments are light brown. The head also is light brown, with a narrow yellow streak through the center. The eyes are dark brown. The thorax is yellowish, with two large brown spots divided by a narrow yellow stripe through the center. A number of moderately conspicuous hairs occur along the abdominal segments.

PREPUPA.

Average measurements of the prepupa (Pl. I, E) are: Length 2.27 mm., width of mesothorax 0.537 mm. Somewhat smaller than the preceding stage and lighter in color. The blotches of pigment now appear larger and not so numerous throughout the body, which is whitish or almost transparent. The head and thorax are white, with little coloring except for the eyes, which are larger and reddish brown. The last abdominal segment is light brown. The legs are colorless and the antennæ, which are short, heavy, and folded back along the head, are also colorless. The wing pads show as short colorless sacs. Numerous long whitish hairs appear on the antennæ and abdomen.

PUPA.

Average measurements of the pupa are: Length 1.98 mm., width of mesothorax 0.417 mm. The pupa (Pl. I, F) is smaller than the prepupa, but similar in color, except for the presence of a little more pigment, particularly in the head and thorax. The antennæ are now longer but folded back along the head. The wing pads are longer, reaching about the third abdominal segment. Numerous long white or colorless hairs are on the legs, antennæ, and abdomen.

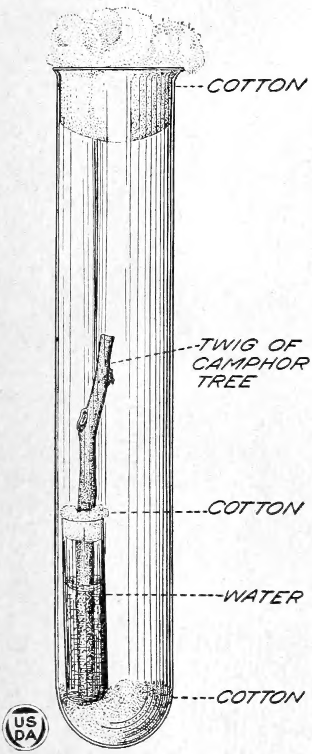


FIG. 6.—Test tube used as a breeding cage for the camphor thrips.

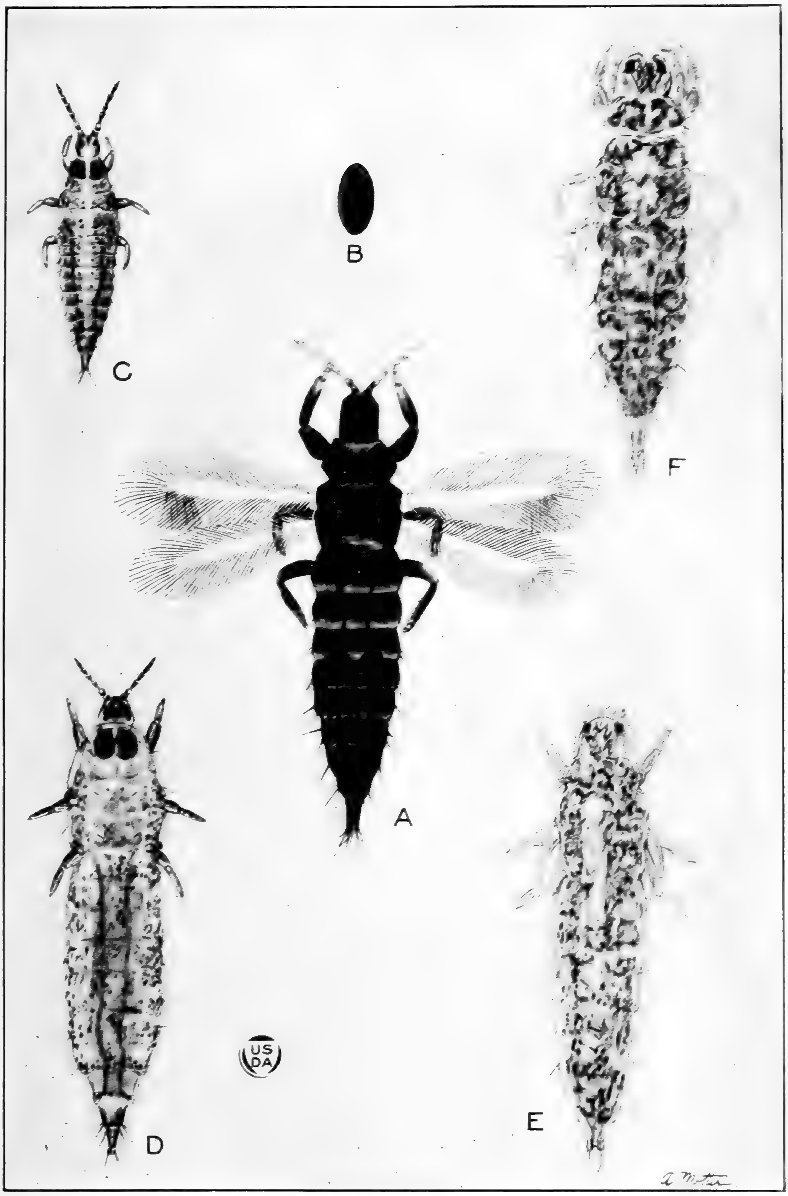
MALES.

In the larval and pupal stages the males are somewhat smaller than the females and have a distinct purple color, but otherwise are similar in structure and appearance. They occur very rarely in nature.

LIFE HISTORY AND HABITS.

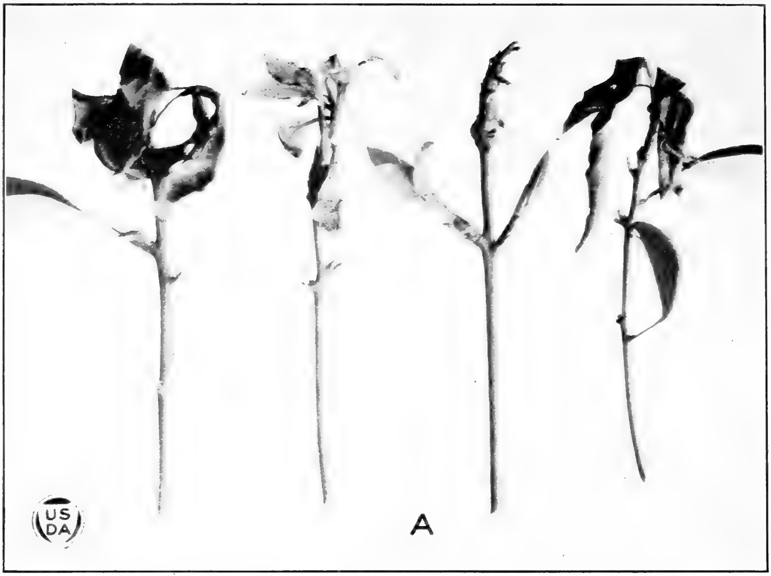
METHODS OF REARING.

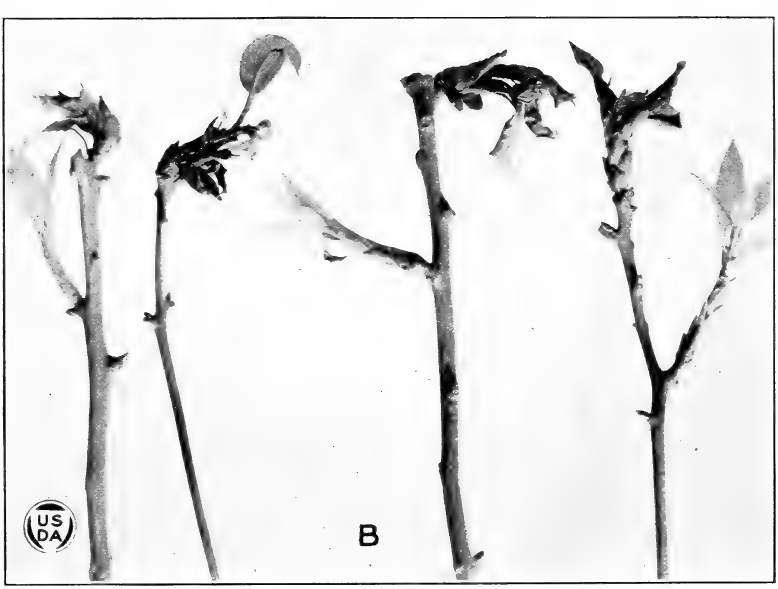
The life history of the camphor thrips was worked out in the laboratory under conditions as nearly natural as possible, with daily observations on the insects infesting growing trees. The work was carried on in summer and also during the cooler weather of winter. Test tubes were employed as breeding cages and the thrips confined on small pieces of camphor twig. (Fig. 6.) The twigs were cut in lengths of about 3 inches and placed in water in small shell vials, the mouth of the vial being filled with cotton which surrounded the twig and held it in place. This vial was then dropped into a test tube and the test tube stoppered with cotton. The immature stages of the thrips were usually held on the camphor twigs by the cotton, but should one succeed in crawling over the cotton it was confined inside of the test tube and could be replaced on the twig. The adults would fly across on to the test tube, but would return to the twigs to feed and oviposit. In all experiments fresh food was given the thrips every few days and they were kept until they died a natural death. Owing to the activity of the thrips and their small size, some of them were lost or injured in transferring to new cages or new food.



THE CAMPHOR THRIPS (CRYPTOTHRIPS FLORIDENSIS).

A, adult female: *B*, egg; *C*, first-stage larva; *D*, second-stage larva; *E*, prepupa; *F*, pupa.

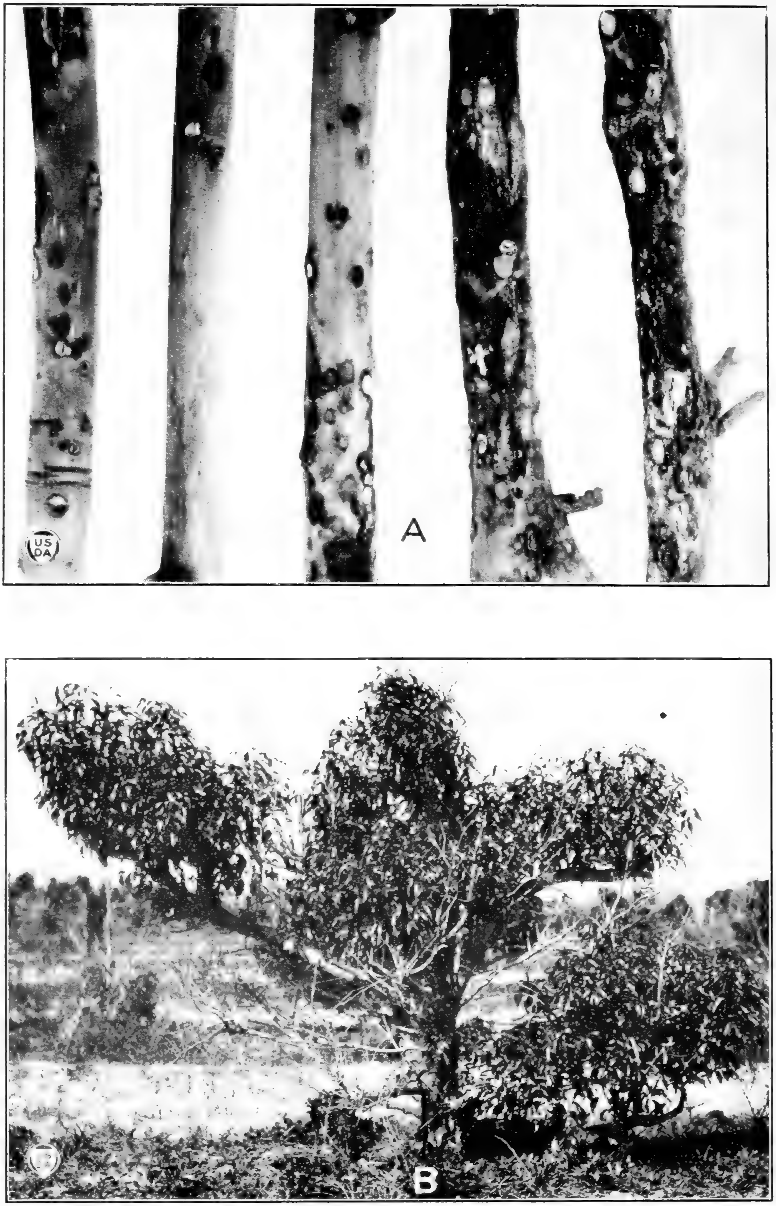




INJURY TO CAMPHOR BUDS CAUSED BY CAMPHOR THRIPS.

The terminal buds are badly deformed or entirely killed.

SMALL LIMBS OF CAMPHOR TREES SHOWING CHARACTERISTIC SPOTS CAUSED BY PUNCTURES OF THE CAMPHOR THRIPS.



INJURY CAUSED BY THE CAMPHOR THRIPS.

A, advanced injury from the camphor thrips, showing cracks or lesions in bark; *B*, camphor trees injured by improper pruning, followed by a heavy infestation of thrips. Several of the branches have been killed.

Hence some difficulty was encountered in keeping the thrips for long periods, and many cultures were started in order to complete the desired number.

DURATION OF LIFE CYCLE.

As observed by the writers, the life cycle of the camphor thrips varied considerably according to the season of the year. In August, 1921, 375 eggs required an average of 6 days in which to hatch, and the combined larval and pupal stages for 57 individuals averaged 12.65 days, giving an average of 18.65 days from egg to adult. The average life of 20 adults during the summer months was 98 days, and they laid an average of 463.7 eggs.

During this period (August, 1921) the maximum temperature at the laboratory in Orlando, Fla., ranged from 88° to 100° F., with a mean maximum of 94° and a mean minimum of 71.2°. The total precipitation was 4.13 inches.

The winter-season breeding work was carried on during November and December, 1921, and January, 1922. During this period 97 eggs required an average of 13.6 days in which to hatch and the combined larval and pupal stages for 40 individuals averaged 24.7 days, making a total of 38.3 days from egg to adult. The average life of 20 adults was 82.8 days, and the average number of eggs laid was 307. The temperatures during this period were as follows: In November, 1921, the maximum temperatures ranged from 71° to 86°, with a mean of 79.5°, and the mean minimum temperature was 53.9°. The total precipitation was 3.62 inches. For December the maximum temperatures ranged from 65° to 80°, with a mean of 74.3°, while the mean minimum was 48.6° and the total precipitation was 2.23 inches. For January, 1922, the maximum temperatures ranged from 61° to 84°, with a mean of 77.3°. The mean minimum was 50.1° and the total precipitation was 0.52 inch.

Allowing for the preoviposition period, which averaged 3.2 days in summer and 7.4 days in winter, the average period of development in summer from egg to egg would be 21.85 days and in winter 45.7 days. Judging from these figures, the maximum number of generations of the camphor thrips per year would be about 12.

THE EGG.

INCUBATION PERIOD.

The time required for development of the egg varies considerably even at the same time of the year. During the warmer weather this period ranges from 5 to 9 days, with an average of 6 days, while in the cooler weather of winter it ranges from 10 to 16 days, with an average of 13.6 days. Thus the egg requires more than twice as long to develop during the cooler part of the year. A variation of 2 or 3 days was also observed in the development of eggs laid on the same day by the same female. The percentage of eggs hatching seems to be very high, averaging 98.2 per cent in summer and 86 per cent in winter. The detailed records on incubation of the egg are given in Table 1.

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TABLE 1.—*Incubation period of camphor thrips eggs.*

IN SUMMER.

Record No.	Date eggs were deposited.	Number of eggs deposited.	Number of eggs developing in specified number of days.					Number of eggs failing to hatch.
			5 days.	6 days	7 days.	8 days.	9 days.	
	1921.							
1.	Aug. 4	3		2	1			0
2.	Aug. 5	10		6	2		1	1
3.	..do....	11		9	1			1
4.	Aug. 6	3		3				
5.	..do....	6	2	3				1
6.	Aug. 7	17	3	8	6			
7.	..do....	8	1	7				
8.	Aug. 8	21	2	10	6	3		
9.	..do....	3		3				
10.	Aug. 9	20	1	10	9			
11.	..do....	2		1	1			
12.	Aug. 10	17	4	11	2			
13.	..do....	23	2	18	3			
14.	Aug. 11	6	2	3	1			
15.	..do....	13	3	10				
16.	Aug. 12	18	3	13	2			
17.	Aug. 13	20	5	10	5			
18.	Aug. 14	16	5	9	2			
19.	Aug. 15	10	6	4				
20.	Aug. 16	32	15	15	2			
21.	Aug. 17	26	1	18	7			
22.	Aug. 18	31	7	22	2			
23.	Aug. 19	18	4	9	5			
24.	Aug. 20	28	9	11	7	1		
25.	Aug. 21	20	3	10	3			4
Total.		382	78	225	67	4	1	7

IN WINTER.

Record No.	Date eggs were deposited.	Number of eggs deposited.	Number of eggs developing in specified number of days.							Number of eggs failing to hatch.
			10 days.	11 days.	12 days.	13 days.	14 days.	15 days.	16 days.	
	1920.									
1.	Nov. 15	9				1	1	2	2	3
2.	Nov. 12	4			1	1		1		1
3.	Nov. 17	2					1	1		0
4.	Nov. 19	3					1	2		0
5.	Nov. 20	2					1			1
6.	Nov. 23	8					4	2		2
7.	..do....	4					1			3
8.	Nov. 29	6			2		3	1		0
9.	Dec. 1	4				1	2	1		0
10.	Dec. 3	3				1	1	1		0
11.	Dec. 6	3						2	1	0
12.	Dec. 9	3					1	2		0
13.	Dec. 11	2					1			1
14.	Dec. 18	2						1		1
15.	Dec. 20	4				1	1	1		1
16.	Dec. 21	2				1	1			0
17.	Dec. 22	2				2				0
18.	..do....	4				1	2	1		0
19.	Dec. 23	4				2	2			0
20.	Dec. 24	4				1	3			0
21.	Dec. 28	3			2	1				0
22.	Dec. 29	3		2	1					0
23.	Dec. 31	2	1		1					0
	1921.									
24.	Jan. 1	2			1	1				0
25.	Jan. 3	4	1	2	1					0
26.	Jan. 4	4	2							2
27.	Jan. 5	2					2			0
28.	Jan. 6	2					2			0
29.	Jan. 7	1					1			0
30.	Jan. 8	1						1		0
31.	..do....	1						1		0
32.	Jan. 9	3					2	1		0
33.	Jan. 10	4					1	3		0
34.	..do....	2						1		1
35.	Jan. 26	4			4					0
Total.		113	4	4	13	14	34	25	3	16

HATCHING.

Hatching has been observed to take place at various times during the day, but in the breeding jars the majority of the thrips seem to hatch during the morning. When ready to hatch, a lidlike cap splits off at the anterior end of the egg, although it remains attached at one side. Sometimes also the egg splits longitudinally, enabling the young thrips to crawl out more easily. It emerges head first and gradually works its way out until it is able to place the front feet on the twig. It then easily draws itself out of the eggshell. When free the thrips at once crawls away in search of food and pays no attention to the empty shell. The entire process of hatching required about 2 minutes in the case of several individuals observed. The empty eggshell does not collapse, but remains intact on the twig, often for a period of several months.

FIRST-STAGE LARVA.

The young thrips begin their search for food as soon as they leave the eggs and remain active throughout their larval period. They are found in cracks and lesions of the bark and on the buds and new terminal growth. The molt takes place almost anywhere on the limbs or leaves. When ready to molt the larva becomes quiescent for a short time, after which the skin splits along the dorsum and the larva easily liberates itself from the old skin.

The first instar in summer lasted from 3 to 7 days in the case of 66 individuals, with an average of 4.05 days. In winter a longer period is required, running from 5 to 10 days, with an average of 7.9 days. Table 2 gives detailed records for the breeding work, the data for summer and winter being shown separately.

SECOND-STAGE LARVA.

Following the first molt the larvæ increase in size rapidly and are more conspicuous on the trees, owing to the prominent orange-red coloring. The larvæ in this stage are also more active and move about rath er rapidly, covering considerable areas of the host plant. When disturbed they quickly crawl around the limb, seeking a bark lesion for safety, or will go down the limb into the interior of the tree. The favorite feeding place seems to be on the buds and new terminal shoots, when there is any new growth on the trees. On cloudy or rainy days, however, or during a period of cold weather the thrips are seldom seen on the leaves and shoots, but remain down in the bark lesions, where they feed on the cambium layer of the wood. Instances have been noted in which they have tunneled back for several inches under the bark or in the center of the limb. When ready to molt again, the larvæ go down under the loose bark or into some crack or lesion, where they pass a brief period of inactivity before shedding the larval skin.

The second stage lasts only slightly longer than the first, but show a greater individual variation. As shown in Table 2, it ranged from 3 to 11 days in summer, with an average of 4.55 days for 59 individuals, and in winter from 6 to 11 days, with an average of 7.94 days.

PREPUPA.

The prepupal stage is passed largely in some lesion under the bark and is of short duration. Although the insects in this stage are able to crawl, they show little activity and probably feed very little.

Both in this stage and also in the pupa stage which follows they are never seen on the leaves and limbs and can be found only by digging into the bark.

The duration of the prepupal stage is usually very brief, less of the life of the thrips being passed in this stage than in any other. During the warm weather most of the thrips remained in this stage only about 24 hours. No specimens in the breeding jars ran over 2 days. The average for 58 individuals was 1.17 days. During the winter months this stage was passed in from 2 to 5 days, with an average of 3.5 days. Table 2 gives detailed records on the length of this stage.

PUPA.

The pupal stage is passed entirely in seclusion in the bark lesions, and the pupæ are never seen on the outside of the tree. The thrips in this state do not move about but remain quiescent, and do not feed. After the final molt the adults emerge from the bark and appear on the limbs and buds.

The pupa stage varied from 1 to 4 days in summer, with an average of 2.89 days. In winter it lasted from 2 to 7 days, with an average of 5.35 days. Even in the colder parts of the State the pupal stage is not of very great duration, for the periods of inactivity caused by unfavorable weather are passed by hibernation of the adults.

TABLE 2.—*Duration of larval and pupal stages of the camphor thrips.*

IN SUMMER.

Record No.	Date hatched.	First instar.		Second instar.		Prepupa.		Pupa.	
		Date of molt.	Length of stage.	Date of molt.	Length of stage.	Date of molt.	Length of stage.	Date of molt.	Length of stage.
	1921	1921	*Days.*	1921	*Days.*	1921	*Days.*	1921	*Days.*
1	Aug. 11	Aug. 16	5	Aug. 20	4	Aug. 21	1	Aug. 24	3
2	...do.....	Aug. 15	4	Aug. 19	4	Aug. 20	1	Aug. 23	3
3	...do.....	...do.....	4	...do.....	4	...do.....	1	Aug. 22	2
4	...do.....	...do.....	4	Aug. 20	5	Aug. 21	1	Aug. 24	3
5	...do.....	...do.....	4	Aug. 19	4	Aug. 20	1	Aug. 23	3
6	...do.....	Aug. 16	5	Aug. 21	5	Aug. 23	2	Aug. 26	3
7	...do.....	Aug. 15	4	Aug. 19	4	Aug. 21	2	Aug. 22	1
8	...do.....	...do.....	4	...do.....	4	Aug. 20	1	...do.....	2
9	...do.....	...do.....	4	...do.....	4	...do.....	1	Aug. 23	3
10	...do.....	Aug. 16	5	Aug. 20	4	Aug. 21	1	Aug. 24	3
11	Aug. 12	...do.....	4	...do.....	4	Aug. 22	2	...do.....	2
12	...do.....	...do.....	4	Aug. 19	3	Aug. 20	1	Aug. 23	3
13	...do.....	...do.....	4	Aug. 20	4	Aug. 22	2	Aug. 24	2
14	Aug. 13	Aug. 18	5	Aug. 21	3	...do.....	1	Aug. 25	3
15	...do.....	...do.....	5	...do.....	3	...do.....	1	...do.....	3
16	...do.....	...do.....	5	...do.....	3	...do.....	1	...do.....	3
17	Aug. 14	...do.....	4	Aug. 22	4	Aug. 23	1	Aug. 26	3
18	...do.....	...do.....	4	Aug. 23	5	Aug. 24	1	Aug. 28	4
19	...do.....	...do.....	4	Aug. 22	4	Aug. 23	1	Aug. 26	3
20	...do.....	...do.....	4	...do.....	4	...do.....	1	...do.....	3
21	...do.....	...do.....	4	Aug. 23	5	Aug. 24	1	Aug. 28	4
22	...do.....	...do.....	4	...do.....	5	...do.....	1	Aug. 27	3
23	...do.....	Aug. 17	3	Aug. 21	4	Aug. 22	1	Aug. 24	2
24	...do.....	Aug. 19	5	Aug. 24	5	Aug. 26	2	Aug. 28	2
25	...do.....	Aug. 18	4	Aug. 22	4	Aug. 23	1	Aug. 27	4
26	Aug. 15	...do.....	3	...do.....	4	...do.....	1	Aug. 26	3
27	...do.....	Aug. 19	4	Aug. 23	4	Aug. 24	1	Aug. 27	3
28	...do.....	...do.....	4	...do.....	4	...do.....	1	Aug. 28	4
29	...do.....	Aug. 18	3	...do.....	5	...do.....	1	Aug. 27	3
30	...do.....	Aug. 19	4	Aug. 24	5	Aug. 25	1	Aug. 28	3
31	...do.....	...do.....	4	Aug. 23	4	Aug. 24	1	Aug. 27	3
32	...do.....	...do.....	4	Aug. 24	5	Aug. 25	1	Aug. 28	3
33	Aug. 16	...do.....	3	Aug. 23	4	Aug. 24	1	Aug. 27	3
34	...do.....	...do.....	3	...do.....	4	...do.....	1	...do.....	3
35	...do.....	...do.....	3	Aug. 24	5	Aug. 25	1	Aug. 28	3
36	...do.....	...do.....	3	Aug. 26	7	Aug. 28	2	Aug. 31	3

Table 2.—*Duration of larval and pupal stages of the camphor thrips*—Continued.

IN SUMMER.

Record No.	Date hatched.	First instar. Date of molt.	First instar. Length of stage.	Second instar. Date of molt.	Second instar. Length of stage.	Prepupa. Date of molt.	Prepupa. Length of stage.	Pupa. Date of molt.	Pupa. Length of stage.
37	...do.....	Aug. 20	4	Aug. 25	5	Aug. 27	2	Aug. 30	3
38	...do.....	...do.....	4	Aug. 24	4	Aug. 25	1	Aug. 28	3
39	Aug. 18	Aug. 22	4	Aug. 26	4	Aug. 27	1	Aug. 30	3
40	...do.....	Aug. 23	5	Aug. 27	4	Aug. 28	1	Aug. 31	3
41	Aug. 17	Aug. 20	3	Aug. 24	4	Aug. 25	1	Aug. 29	4
42	...do.....	...do.....	3	...do.....	4	...do.....	1	Aug. 28	3
43	...do.....	Aug. 22	5	Aug. 26	4	Aug. 27	1	Aug. 30	3
44	...do.....	Aug. 21	4	...do.....	5	...do.....	1	...do.....	3
45	...do.....	Aug. 20	3	Aug. 25	5	...do.....	2	Aug. 29	2
46	Aug. 18	Aug. 22	4	Aug. 26	4	...do.....	1	...do.....	2
47	...do.....	...do.....	4	Aug. 27	5	Aug. 28	1	Aug. 31	3
48	Aug. 19	Aug. 23	4	Aug. 28	5	Aug. 30	2	Sept. 2	3
49	...do.....	...do.....	4	Aug. 27	4	Aug. 28	1	Aug. 31	3
50	Aug. 18	Aug. 22	4	Sept. 2	11	Sept. 3	1	Sept. 6	3
51	Aug. 20	Aug. 24	4	Aug. 29	5	Aug. 30	1	Sept. 2	3
52	Aug. 19	...do.....	5	Aug. 30	6	Aug. 31	1	Sept. 3	3
53	Aug. 20	...do.....	4	Sept. 3	10	Sept. 5	2	Sept. 7	2
54	Aug. 11	Aug. 18	7	Died....					
55	Aug. 12	Aug. 16	4	Aug. 20	4	Died....			
56	...do.....	Aug. 17	5	Lost....					
57	Aug. 13	...do.....	4	Died....					
58	Aug. 14	...do.....	3	Aug. 21	4	Aug. 22	1	Died....	
59	...do.....	...do.....	3	Died....					
60	Aug. 15	Aug. 19	4	...do.....					
61	...do.....	...do.....	4	Aug. 24	5	Lost....			
62	Aug. 16	...do.....	3	Aug. 23	4	Aug. 24	1	Aug. 28	4
63	...do.....	Aug. 20	4	Aug. 24	4	Aug. 25	1	...do.....	3
64	Aug. 19	Aug. 23	4	Died....					
65	Aug. 20	Aug. 24	4	Aug. 30	6	Aug. 31	1	Sept. 2	2
66	...do.....	Aug. 26	6	...do.....	4	...do.....	1	Sept. 3	3
Average			4.05		4.55		1.17		2.89

IN WINTER.

Record No.	Date hatched.	First instar. Date of molt.	First instar. Length of stage.	Second instar. Date of molt.	Second instar. Length of stage.	Prepupa. Date of molt.	Prepupa. Length of stage.	Pupa. Date of molt.	Pupa. Length of stage.
	1920–21.	1920–21.	*Days.*	1920–21.	*Days.*	1920–21.	*Days.*	1920–21.	*Days.*
1	Nov. 20	Nov. 29	9	Dec. 6	7	Died....			
2	...do....	Nov. 30	10	Lost....					
3	Nov. 28	Dec. 5	7	Died....					
4	Dec. 1	Dec. 10	9	Dec. 18	8	Dec. 23	5	Dec. 28	5
5	Dec. 2	Dec. 11	9	Dec. 22	11	Dec. 26	4	Dec. 30	4
6	Dec. 3	Dec. 12	9	Dec. 21	9	...do....	5	...do....	4
7	Dec. 7	Dec. 14	7	Dec. 22	8	...do....	4	Jan. 2	7
8	Dec. 11	Dec. 21	10	Dec. 29	8	Jan. 1	3	Jan. 6	5
9	Dec. 13	Dec. 23	10	Dec. 31	8	Jan. 3	3	Jan. 7	4
10	...do....	Dec. 22	9	Dec. 29	7	Jan. 1	3	Jan. 6	5
11	...do....	Dec. 23	10	Dec. 31	8	Jan. 3	3	Jan. 7	4
12	Dec. 14	Dec. 22	8	Dec. 29	7	Jan. 1	3	Jan. 6	5
13	Dec. 21	Dec. 29	8	Jan. 5	7	Jan. 7	2	Jan. 12	5
14	Jan. 2	Jan. 9	7	Jan. 17	8	Jan. 21	4	Jan. 27	6
15	...do....	Jan. 8	6	Jan. 15	7	Jan. 20	5	Jan. 26	6
16	Jan. 3	Jan. 9	6	Jan. 18	9	Jan. 21	3	Jan. 27	6
17	...do....	...do....	6	Jan. 19	10	Jan. 22	3	Jan. 30	8
18	Jan. 4	...do....	5	Jan. 17	8	...do....	5	Jan. 27	5
19	...do....	Jan. 10	6	Died....					
20	...do....	Jan. 9	5	Jan. 17	8	Jan. 21	4	Jan. 27	6
21	...do....	Jan. 10	6	Jan. 19	9	Jan. 23	4	Jan. 29	6
22	Jan. 5	Jan. 11	6	Died....					
23	Jan. 6	Jan. 14	8	Jan. 24	10	Died....			
24	...do....	...do....	8	Jan. 23	9	Jan. 27	4	Feb. 1	5
25	Jan. 7	Jan. 15	8	Jan. 24	9	Died....			
26	Jan. 20	Jan. 26	6	Feb. 2	7	Feb. 4	2	Feb. 9	5
27	Jan. 21	Jan. 30	9	Feb. 7	8	Feb. 9	2	Feb. 11	2
28	Jan. 23	Jan. 31	8	...do....	7	...do....	2	Feb. 14	5
29	Jan. 24	Feb. 2	9	Feb. 8	6	Feb. 10	2	Feb. 16	6
30	Jan. 9	Jan. 19	10	Jan. 26	7	Jan. 31	5	Feb. 6	6
31	...do....	...do....	10	...do....	7	...do....	5	...do....	6
32	Jan. 24	Feb. 2	9	Feb. 7	5	Feb. 9	2	Feb. 14	5
33	Jan. 10	Jan. 19	9	Jan. 26	7	Jan. 31	5	Feb. 6	6
34	Jan. 12	Jan. 21	9	Jan. 31	10	Feb. 3	3	Feb. 8	5
35	Jan. 13	...do....	8	...do....	10	Lost....			
36	...do....	Jan. 20	7	Jan. 29	9	Feb. 2	4	Feb. 7	5
37	Jan. 14	Jan. 21	7	Jan. 28	7	Jan. 31	3	Feb. 6	6
38	...do....	...do....	7	...do....	7	Feb. 1	4	Feb. 8	7
39	Jan. 19	Jan. 26	7	Feb. 1	6	Feb. 4	3	Feb. 10	6
Average			7.9		7.94		3.5		5.35

ADULT.

DURATION OF LIFE.

The length of life of the adult insects is extremely variable. A series of 20 thrips becoming adult in the winter season from November 8 to February 8 (Table 3) lived an average of 82.85 days. The longest life ran from November 12 to April 4, or 143 days, while the shortest was 28 days, January 7 to February 4. A series of 20 thrips which became adult in August (Table 3) lived an average of 98 days. The longest was 196 days, August 24 to March 8, and the shortest 41 days, August 24 to October 4. The average for these runs higher than for those maturing in winter, several of them living over four months. Field observations tend to confirm these results, for many of the thrips maturing in summer hibernate, while those maturing in winter live only long enough to start the breeding season in spring. When kept without food the insects usually lived only 2 or 3 days, with an occasional specimen lasting 5 or 6 days.

OVIPOSITION.

Portion of plant selected.—The favorite place for depositing eggs is in cracks or lesions of the bark resulting from the feeding of the larvæ or from injury from other causes. The eggs are sometimes crowded into a small crack in large numbers, as many as 100 being often observed. Some eggs are placed in the leaf axils or on leaf scars and also along the bud scales. Another favorite place for oviposition is on the end of a cut stem or limb. When trees were pruned back in experimental work many eggs were deposited on the upper ends of the stubs of the limbs. In the breeding jars in the laboratory the favorite place for placing eggs was on the cut stems. Eggs are sometimes forced down into the wood on these cut surfaces. The end of a limb from a tree which had been pruned back for experimental purposes was observed to have eggs on it, and when closely examined under the binocular it was seen that several eggs had been inserted between the layers of wood, some as deep as one-eighth inch. Another place often selected for oviposition in the breeding jars was along the stems just under the cotton surrounding them in the vials. Under natural conditions the camphor thrips will seldom lay an egg on an exposed smooth surface of a limb or leaf, but always tries to select a crack in the bark or other place which offers some protection.

Description of process.—The act of oviposition has been observed many times in the breeding jars. The eggs are quickly passed from the body and seemingly with little difficulty on the part of the female, the process usually requiring about two minutes. On one occasion a thrips was seen to crawl up to a crack on the bark of a limb which already contained 2 eggs, and place the end of her abdomen in the opening near the eggs, remaining quiet for about 30 seconds. She then turned around and brushed her antennæ over the place a few times. Again turning, she placed her ovipositor in the location selected and at once deposited the egg. Some muscular contractions were observed throughout the body, particularly in the abdomen, which was also moved up and down. The abdomen then enlarged towards the

tip as the egg moved along, the egg easily slipping out when it reached the end. The female immediately crawled away without looking at the egg. On another occasion a female crawled up to the top of a limb in a jar and immediately deposited an egg on the cut surface. Then she at once crawled away, the entire operation requiring no more than 30 seconds.

Rate of oviposition and number of eggs laid.—The rate of oviposition is dependent to a considerable extent on the weather. Many more eggs are laid on bright warm days than on cloudy or cold days. The average for 20 individuals in summer was 5.1 eggs per day throughout the egg-laying period, while in winter there was an average of 4.19 per day for 20 individuals. After a brief preoviposition period amounting to 3.2 days on the average in summer and 7.4 days in winter, the females begin egg laying. The number of eggs laid per day has varied from none up to 13 in one case, but will average about 4 or 5. As will be noted in Table 3, some females are much more productive than others, even when kept under identical conditions. In the breeding jars some insects have laid from 7 to 10 or 11 eggs per day over a considerable period. Toward the end of their life the number of eggs per day diminishes, and finally ceases, being followed by a brief postoviposition stage. This period of inactivity varied from 1 to 14 days, with an average of 4.4 days for summer and 2.7 days for winter. The average length of the egg-laying stages was 90.4 days and the average total number of eggs 463.7 in summer. For winter the average of the egg-laying stages was 73.3 and the average total number of eggs 307. The greatest number of eggs laid by an individual thrips was 684.

TABLE 3.—*Length of life of adults of the camphor thrips, showing length of egg-laying, preoviposition, and postoviposition periods, together with number of eggs laid.*

IN SUMMER.

Record No.	Date adult emerged.	Date first egg laid.	Length of preoviposition period.	Date last egg laid.	Length of egg-laying period.	Date of death.	Length of postoviposition period.	Total length of life.	Total number of eggs laid.
	1921.	1921.	*Days.*	1921–22.	*Days.*	1921–22.	*Days.*	*Days.*	
1	Aug. 22	Aug. 25	3	Oct. 24	60	Oct. 26	2	65	488
2	Aug. 23	Aug. 26	3	Nov. 26	92	Nov. 30	4	99	559
3	Aug. 22	...do...	4	Nov. 3	69	Nov. 5	2	75	484
4	Aug. 23	...do...	3	Oct. 24	59	Oct. 26	2	64	434
5	Aug. 24	Aug. 27	3	Oct. 29	63	Oct. 31	2	68	360
6	...do...	...do...	3	Oct. 1	35	Oct. 4	3	41	280
7	Aug. 23	...do...	4	Dec. 20	115	Dec. 23	3	122	496
8	Aug. 24	...do...	3	Oct. 4	38	Oct. 8	4	45	242
9	...do...	...do...	3	Dec. 27	122	Jan. 3	7	132	656
10	...do...	...do...	3	Oct. 14	48	Oct. 21	7	58	136
11	Aug. 25	Aug. 28	3	Dec. 15	109	Dec. 19	4	116	516
12	Aug. 24	Aug. 29	5	Mar. 4	187	Mar. 8	4	96	684
13	Aug. 25	...do...	4	Dec. 27	120	Jan. 3	7	131	465
14	Aug. 26	...do...	3	Jan. 3	127	Jan. 9	6	136	508
15	...do...	...do...	3	Oct. 29	61	Nov. 1	3	67	430
16	...do...	...do...	3	Jan. 23	147	Feb. 2	10	160	672
17	Aug. 28	Aug. 30	2	Nov. 10	72	Nov. 16	6	80	521
18	Aug. 27	...do...	3	Jan. 5	128	Jan. 9	4	135	578
19	...do...	...do...	3	Dec. 16	108	Dec. 19	3	114	538
20	Aug. 31	Sept. 3	3	Oct. 21	48	Oct. 26	5	56	227
Average			3.2		90.4		4.4	98	463.7

TABLE 3.—*Length of life of adults of the camphor thrips, showing length of egg-laying, preoviposition, and postoviposition periods, together with number of eggs laid*—Con.

IN WINTER.

Record No.	Date adult emerged.	Date first egg laid.	Length of preoviposition period.	Date last egg laid.	Length of egg-laying period.	Date of death.	Length of postoviposition period.	Total length of life.	Total number of eggs laid.
	1920–21.	1920–21.	*Days.*	1921.	*Days.*	1921.	*Days.*	*Days.*	*Eggs.*
1	Dec. 1	Dec. 8	7	Mar. 12	94	Mar. 14	2	103	365
2	Nov. 8	Nov. 14	6	Mar. 18	124	Mar. 19	1	131	489
3	Nov. 12	Nov. 17	5	Apr. 3	137	Apr. 4	1	143	348
4	Nov. 17	Nov. 22	5	Feb. 7	77	Feb. 8	1	82	211
5	Dec. 28	Jan. 7	10	Mar. 26	78	Mar. 28	2	90	219
6	Dec. 30	Jan. 6	7	Apr. 26	110	Apr. 28	2	119	553
7	Jan. 2	Jan. 9	7	Mar. 19	69	Mar. 21	2	78	117
8	Jan. 7	Jan. 13	6	Apr. 7	84	Apr. 9	2	92	405
9	do	Jan. 15	8	Jan. 25	10	Feb. 4	10	28	25
10	Jan. 12	Jan. 22	10	Apr. 3	71	Apr. 5	2	83	320
11	Jan. 26	Feb. 3	8	May 10	96	May 11	1	105	401
12	Jan. 29	Feb. 8	10	Mar. 20	40	Mar. 21	1	51	144
13	Feb. 9	Feb. 18	9	Apr. 29	70	May 1	2	81	251
14	Feb. 1	Feb. 8	7	Mar. 26	47	Mar. 28	2	56	253
15	Feb. 14	Feb. 25	11	Apr. 9	43	Apr. 9	0	54	341
16	Feb. 6	Feb. 11	5	June 4	113	June 6	2	120	553
17	do	Feb. 14	8	Mar. 19	33	Mar. 20	1	42	154
18	Feb. 8	do	6	Apr. 24	69	Apr. 25	1	76	404
19	Feb. 6	Feb. 11	5	Mar. 20	47	Apr. 3	14	56	260
20	Feb. 8	Feb. 16	8	Apr. 11	54	Apr. 16	5	67	327
Average			7.4		73.3		2.7	82.85	307

PARTHENOGENESIS.

Reproduction of the camphor thrips seems to be almost entirely by parthenogenesis. No males have ever appeared in the breeding jars at any time of the year. Occurring in nature rather rarely, it is doubtful if the males fulfill any necessary rôle in the propagation of the species. Large numbers of the adults captured from trees and placed together in jars have never shown any tendency toward mating. The fact that isolated females have been reared for many successive generations proves that they can reproduce throughout the year parthenogenetically. The male larvæ, which are rather conspicuous because of their purple coloring, were found most abundant in January on the trees in the laboratory yard. Some occurred throughout the spring and until June, but none were seen during the summer. These larvæ when raised to adults in jars and placed together with recently matured females were never seen to mate. Neither did these females produce any offspring which showed any purple color like the immature males. In fact a purple larva never was produced in any of the life-history work.

FLYING HABITS.

Although provided with fully developed wings, the thrips seldom fly, and flight is a small factor in the distribution of the species. The maximum flight which has been observed was only a few feet. Watson (*2*) also states that the thrips seem to be incapable of flight. On a few occasions adult thrips were seen to fly from one limb to another, but it is very doubtful if they ever attempt any long flight, such as from one field of camphors to another, and seldom even from one tree to another. In the breeding jars the adults often fly from the camphor limb to the sides of the jar, and on one occasion a

thrips which escaped from a jar flew to a window about 3 feet away. When disturbed on the trees the adults will crawl around the limb or enter some lesion rather than fly away.

The natural distribution of the species also tends to prove that flight is of little importance as a means of spreading the insects. Sometimes in borders of camphor trees along a street some trees are infested while others are entirely free. Camphor trees have remained free from thrips for several years within a few rods of an infested hedge. Trees planted on farms often remain free when the thrips occur on other farms less than a mile away. On the other hand, practically all the trees in the fields of the camphor plantations where regular cultivation is practiced are infested. This would indicate that the thrips are spread by workmen or teams much more than by flight. Probably the greatest factor in distributing the insects over the State has been the movement of infested trees and nursery stock.

FEEDING HABITS.

All portions of the tree are subject to attack by the thrips except the roots. During the periods of growth the new buds seem to be the favorite food, but later the thrips attack the young shoots and limbs and also work in the cracks and lesions of the older limbs. The greatest injury to the trees probably results from the work of the thrips in the buds. Larvæ and adults both feed about the bud scales and cause the buds to turn black and die. The entire new flush of growth on a tree is sometimes killed in this way. This type of injury is illustrated in Plate II. The tender young shoots are blackened also in spots by the punctures of the insects, as shown in Plate III. One thrips is capable of blackening a considerable area of bark in a single day by its feeding punctures. This work is done mostly by the larvæ. Although the adults are often seen running about over the leaves and limbs and cause some of the injury, they do not feed so much in exposed places as they do in the bark lesions. As the limbs grow older these blackened spots become dead areas over which the bark cracks (Pl. IV, A). Deep cracks or lesions result later, the injury often being aggravated by further feeding of the thrips on the cambium layer of the wood inside these lesions. At times this advanced stage of injury even deforms the limbs (Pl. V). When once the insects are inside of the limb they will often tunnel back for several inches by hollowing out the pith of the stem. In these secluded places the pupa stages are passed, and here also the larvæ and adults pass periods of rainy or other unfavorable weather, and even hibernate in some cases.

The camphor thrips, however, should not be charged with all the injury done to the buds. Fields of camphor trees have been observed which showed a considerable number of blackened buds and dead shoots caused by *Heilipus apiatus* Oliv. This large and conspicuous black and white weevil gouges out the sides of the stems near the tips. The entire new growth on the limb then dries up and turns black. The effect of this injury on a field of young camphor trees is similar to that caused by the thrips.

SEASONAL HISTORY.

In the warmer parts of Florida the camphor thrips is active and reproduces at all times of the year, but in the more northern parts of the State, especially at Satsuma and Waller, where the largest number of camphor trees are growing, it is doubtful if they reproduce through the winter. Professor Watson states that breeding ceases at Gainesville during the winter. Adults are known to hibernate there, and it is difficult to find young larvæ during the colder months. Such is not the case at Orlando, however. The breeding experiments recorded in this bulletin were conducted through the winter at the laboratory in Orlando but under natural climatic conditions. Checks and daily observations made on trees growing in the laboratory yard have confirmed the results as given, and show that the thrips exist in all stages throughout the year.

During the late fall and winter months the thrips were especially abundant on the trees at Orlando, perhaps more so than at any other time of the year. On April 1 fewer thrips were noted, and they continued to decrease in numbers for about two months. The same condition existed at the camphor plantation at Satsuma. During April and May very few thrips were in evidence, and the camphor growers reported that they were never injurious at that time of year. During June they began to appear in considerable numbers and caused injury to the trees, being found mostly on the young buds, many of which were blackened and killed. The thrips continued to work on the trees throughout the summer, feeding on the bark when there are no buds or new growth. At Satsuma their activity ceases about November and little breeding takes place until March, unless spells of warm weather occur during the winter. At Orlando, however, they continued to live and increase on the camphor trees throughout the winter

It was always observed that no thrips were in evidence on the trees on a cold morning. When the temperature was down to 50° F. they remained down in the bark lesions on the older limbs. It was not until the sun had warmed up the atmosphere that they would come out on the bark and leaves to feed. By cutting open the lesions the insects could be found in all stages. They feed there on the bark and cambium tissues and often remain for several days at a time if weather conditions are unfavorable. In fact it is in these lesions that the adults hibernate through the entire winter in the northern part of the State. Cloudy or rainy weather even in summer has a tendency to drive the thrips to the shelter of the bark lesions. They show a decided positive reaction to sunlight and are found in the tops of the trees on bright days only.

HOST PLANTS.

As far as is known, the camphor thrips will live only on the camphor tree, *Cinnamomum camphora* (L.) Nees & Eberm. Experiments were conducted to determine if it would live on other closely related trees, including bays (*Persea* spp.), avocado, *Persea americana* Mill., and sassafras, *Sassafras variifolium* (Salisb.) Kuntze. These are included with the camphors in the family Lauraceae and are native in the parts of Florida where the camphors grow. It was thought

that the camphor thrips might have been a native insect living on some of these trees, and had taken to the camphor because of their close botanical relationship. No evidence to support this theory has been found, however.

BAYS.

Efforts were made to rear the camphor thrips on twigs of bay trees cut and brought into the laboratory, using the same type of cage as previously described for the life-history work on camphor twigs (fig. 6). The results of this work are given in Table 4, which shows the length of time each lived. Three species of bays were used, the swamp bay, *Persea palustris*, the red bay, *P. borbonia*, and the shore bay, *P. littoralis*. Observations were made on the scrub bay, *P. humilis*, in its natural habitat, but trees of this species were not available near the laboratory where they could be used for experimental feeding.

TABLE 4.—*Length of life of camphor thrips when fed on bay-tree twigs (1920–21).*

[a=adult; l=larva; p=pupa.]

Date.	Number placed on bay.	Died.
Dec. 14	5 a, 5 l	Dec. 27, 1 a, 4 l; Dec. 30, 1 p; Jan. 3, 1 a; Jan. 6, 1 a; Jan. 8, 1 a; Jan. 10, 1 a.
Dec. 14	5 a, 5 l	Dec. 20, 2 l; Dec. 22, 3 l; Dec. 24, 2 a; Dec. 27, 1 a; Dec. 29, 1 a; Dec. 30, 1 a;
Dec. 30	4 a, 4 l	Jan. 4, 4 l; Jan. 11, 3 a; Jan. 18, 1 a.
Jan. 18	4 a, 4 l	Jan. 22, 4 l, 1 a; Feb. 2, 1 a; Feb. 8, 1 a; Feb. 10, 1 a.
Jan. 18	4 a, 4 l	Feb. 8, 3 a, 4 l; Feb. 10, 1 a.
June 8	3 a	June 13, 1 a; June 16, 2 a.
June 22	4 a	June 27, 4 a.
July 5	2 a	July 9, 1 a; July 11, 1 a.
July 5	8 l	July 9, 3 l; July 11, 1 a, 3 l; July 12, 1 l.
Aug. 4	5 l	Aug. 11, 4 l; Aug. 15, 1 a.
Aug. 4	4 a	Aug. 7, 1 a; Aug. 11, 3 a.
Aug. 23	9 l	Aug. 24, 4 l; Aug. 26, 5 l.

The data in Table 4 show that camphor thrips larvæ can not live on bay-tree cuttings. In a few cases they became adult, but most of the larvæ died after a few days. The adults lived longer, one of them reaching 23 days. In nearly all of the cages the adults laid some eggs, but more of them were on the cotton stoppers than on the bay-tree twigs. In only a very few cases did any eggs hatch, and the young larvæ could not then be found. They evidently died from lack of proper food.

Thrips were also placed in cages tied over limbs of a growing bay tree. On March 15, 1921, 5 cages containing 20 thrips each, in all stages, were tied on limbs of *Persea palustris*. On opening the cages, April 6, some adults were found in one cage only. No eggs or larvæ were present. June 4 the cages contained no thrips in any stages. They evidently failed to reproduce on the bay tree.

A similar experiment was performed later on the same tree. Three small wire cages were tied on limbs of the tree on August 12, and a dozen thrips liberated in each. After 6 days they were opened and no live thrips or eggs could be found in any cage.

On May 6 several cages containing a dozen thrips each were tied on limbs of the shore bay, *P. littoralis*, at Daytona Beach. After 7 days one cage was found to have a few live adults, but on May 28 no thrips or eggs could be found in any cage.

On July 7 a wire cage was placed over a small bay tree, *P. borbonia*, planted near the laboratory, and several thrips in all stages released in it. Many more thrips were added to the tree at intervals of every few days until September 10. In no case were any live thrips found on the tree more than one day after releasing them.

All of these experiments prove that the camphor thrips will not live on bay trees for any length of time. The adults in a few cases have survived for a short time, but they will not reproduce and maintain themselves there.

AVOCADO.

The avocado, being a close relative of the camphor tree, was also tried as a food plant. Cuttings from the limbs were used as food in the same manner as in the experiments with camphor and bay twigs. The results as recorded in Table 5 are similar to those obtained with the bay. Most of the larvæ died before becoming adult. The adults lived a maximum of 31 days. Although many eggs were laid in the cages and a few of them hatched out, the young larvæ would not live on the avocado and soon died.

TABLE 5.—*Length of life of camphor thrips on avocado (1920–21).*

[a=adult; l=larva; p=pupa.]

Date.	Number placed on avocado.	Died.
Dec. 23	3 a, 5 l	Dec. 31, 2 l; Jan. 7, 1 l; Jan 10, 2 l; Jan. 17, 2 a; Jan. 20, 1 a.
Dec. 23	5 a, 5 l	Jan. 6, 1 a; Jan. 8, 1 a; Jan. 10, 2 a, 1 l; Jan. 15, 2 a; Jan. 17, 2 a; Jan. 23, 1 a.
Dec. 30	4 a, 4 l	Jan. 11, 2 l; Jan. 12, 1 a; Jan. 18, 1 a; Jan. 21, 3 a; Jan. 22, 1 a.
July 5	1 a, 1 p	July 8, 1 a; July 12, 1 a.

A large number of camphor thrips were placed on a small avocado tree in the laboratory yard, but after two days all had disappeared. Other avocado trees are growing in a row of camphor trees which are infested with thrips, but have never been found to have any thrips on them.

On March 7 some cages containing both adults and larvæ from camphor trees were tied over limbs of a large avocado tree. After one month the cages were opened and one of them was found to contain 2 young larvæ of the camphor thrips. These larvæ certainly had been reared from eggs laid by the adults in the cages. Three weeks later, however, no thrips could be found in the cage, and it was concluded that the camphor thrips can not maintain itself on the avocado tree.

SASSAFRAS.

In a similar manner efforts were made to feed camphor thrips on sassafras, also a tree closely related to camphor. The results were similar to those recorded for the bay and the avocado. Practically all the larvæ died before reaching maturity, and the greatest length of life for the adults was 30 days. Most of them died after about two weeks. A very few eggs were deposited, but in no case did any of the larvæ hatching therefrom live.

OCOTEA.

Another genus closely related to Camphor is Ocotea, which is represented in the southern part of Florida by the lancewood, *Ocotea catesbyana* (Michx.) Sarg. Professor Watson found that efforts to feed camphor thrips on this plant met with negative results. The larvæ died in 48 hours and the adults lived only a few days. He also made an extended search of the trees in their natural habitat and found no thrips on them.

OTHER PLANTS.

Some thrips were fed on orange and oak branches also. On orange an adult lived 23 days and several larvæ from 4 to 12 days. On oak several larvæ lived also for 10 or 12 days, and adults for longer, one as long as 24 days. In neither case did they lay any eggs on the plants. These experiments show, however, that life can be maintained for a short time on almost any kind of plant food. Even when fed on dead camphor wood, one adult lived for 21 days, although most of them died in a very few days. When confined in jars without any food the thrips always died in less than a week. Eggs, however, were sometimes laid on the cotton stoppers. Checks were conducted on all these experiments by feeding thrips on live camphor wood under the same conditions, and in every case they were alive when the experiments were terminated.

NATURAL ENEMIES.

The camphor thrips is known to be the prey of lady-beetles (family Coccinellidæ) and doubtless has other insect enemies, both predacious and parasitic. A lady-beetle larva was found feeding upon the immature thrips on a camphor tree, and when confined in a vial ate both larvæ and adults. No specific determination of this predator was possible because the larva died before reaching maturity. An adult of the lacewing fly *Crysopa oculata* Fab. was found in a cage over a small camphor tree and no doubt had fed on the thrips. Several dead specimens of camphor thrips collected in the field and some found in the breeding jars had been attacked by a fungus, but it is not known whether this fungus was the cause of their death. Two insect enemies of the closely related bay thrips, *Cryptothrips laureli*, doubtless prey upon the camphor thrips also. These are an internal hymenopterous parasite, *Tetrastichus* sp., and a predacious bug, *Anthocoris* sp.

CONTROL MEASURES.

SPRAYING.

As the camphor thrips spend the greater part of their life within the cracks and lesions of the bark and in other protected places, it usually is impossible to reach them with any spray material. Even the most thorough application when applied at a high pressure will have no effect on them when in these protected places. As a result a satisfactory control can not be obtained by spraying, although on warm bright sunshiny days, when the adults and larvæ are feeding on the buds and young leaves and running about over the trees, it is possible to obtain a fair percentage of mortality by spraying.

The camphor thrips can be readily killed with a solution consisting of ½ pound of 40 per cent nicotine sulphate, 2 quarts of potash-fishoil soap, and 2 quarts of lime-sulphur solution to 50 gallons of water. This spray will kill all thrips which are hit by it. If it is applied when the insects are present on the foliage in the greatest abundance, it will reduce their numbers to a large extent. The addition of the lime-sulphur solution and soap gives the spray combination a greater penetrating power than the tobacco extract alone and this seems to be an essential quality.

On August 15, 1921, a row of camphor trees was sprayed with this spray combination. The spray was most thoroughly applied at 200 pounds pressure and the trees were drenched both inside and out. The sun was shining brightly at the time and the temperature was about 90° F. A large number of thrips were in the buds and on the foliage, but of course many of them were also in the bark lesions. On the following day, August 16, an examination showed only 1 dead larva and no living thrips, either adults or larvæ, on the buds or new growth. On August 19, four days after the spraying had been done, a very careful examination was made. No live thrips were found on the leaves or buds, but 1 living adult and 2 living larvæ were cut out of the limbs. Several dead adults were also seen, some in cracks and lesions and others on the limbs. There is no doubt that the spray killed all the adults and larvæ that it hit, but of course some of the insects were so thoroughly protected in the bark lesions that they could not be reached. On August 22 a further examination showed that practically all of the thrips in the buds had been killed. The examination showed only 1 live adult and 1 first-stage larva. It should be stated, however, that a heavy rain took place on August 21 which may have washed some of the insects away. On unsprayed trees in adjoining rows not more than 10 feet away many times more living thrips were present than on the sprayed row. Prof. J. R. Watson (*3*) also has had satisfactory results in killing the insects with this spray.

Although it is generally admitted that the nicotine in the foregoing combination spray is the killing agent, it appears that the addition of lime-sulphur solution produces a much higher mortality. On June 17 a row of camphor trees abundantly infested with camphor thrips was thoroughly wet, both inside and outside, with a spray containing 2 pounds of potash-fishoil soap and 1 pound of 40 per cent nicotine sulphate to 50 gallons of water. The morning was bright and the temperature high, and many thrips were feeding on the buds and crawling over the branches. On examination, within 10 minutes after the spray had been applied, several of the thrips seemed to be paralyzed. They were on their backs and kicking but were still alive. The limbs were still wet and the thrips were held in the liquid. At the expiration of an hour, when the spray had dried, 7 dead adults were found, besides 5 living adults, 5 dead larvæ, and 10 living larvæ. Some of the live ones were kicking and it was doubtful if they would recover. After three hours, however, many living adults and larvæ were present on the trees. At 1.30 in the afternoon, or five hours after the spraying, many living adults and larvæ were also found. There were not so many adults as in the morning, but some of them may have crawled back into the lesions in the bark. On the following day there appeared

to be practically as many adults and larvæ present as on the unsprayed checks and no dead insects were found. On June 21, which was a bright, warm day, several adult thrips were found in the space of a very few minutes. They continued to feed on the young shoots and the spray apparently did them little or no harm. It was very obvious that this spray, without the lime-sulphur solution, was not satisfactory. It was much less effective than when the lime-sulphur solution was added.

Several experiments were also conducted to determine the effect of the lime-sulphur, tobacco, and soap combination spray upon the camphor thrips eggs. On August 23 twenty-three eggs which had been deposited August 22 and 23 were dipped in some of the solution which had been used for spraying the camphor trees. On August 27 no eggs had hatched. Two days later the eggs still had not hatched, but appeared to be in perfect condition. The checks at this time were hatching. On August 30 all the treated eggs were broken and found to be dried out or to contain a partly developed embryo. All of the eggs were dead. Again on August 31 a limb containing camphor thrips eggs of various ages was dipped in the same solution. Some of these eggs were hatching on the day they were treated. September 1 two eggs hatched and each of the larvæ was found dead near the eggshell from which it had emerged. On September 2 no eggs hatched. From September 3 to 5 a few eggs hatched and the larvæ were found crawling on the limbs. Of the eggs present on August 31 only a small percentage hatched. The dipping tests certainly indicate that practically all eggs which are wet by the spray will fail to hatch. The check eggs all hatched in the normal time. Where the main object is to kill the eggs, it would be advisable to make the solution somewhat stronger than that used in these tests.

Several experiments were conducted in dusting infested camphor trees with lead arsenate, calcium arsenate, flour of sulphur, flowers of sulphur, dry lime-sulphur, and Bordeaux powder. These dusts were used both separately and in various combinations with each other and with lime, but in all cases positive killing effects were lacking. Dusts containing nicotine sulphate were not available at the time.

PRUNING.

Under the system of pruning as practiced on semicommercial plantations, in which the growth was cut back without regard to the location of the nodes, or the trees were dehorned at a height of from 4 to 6 feet (Pl. IV, B; Pl. VI, A), the pruning not only was injurious to the trees but stimulated their growth so that they were not resistant to cold. This method also seemed to produce an unlimited food supply for camphor thrips, and following such pruning they appeared in countless numbers. It was obvious that a different system of pruning must be adopted which would avoid not only the direct injury to the camphor trees but also the secondary damage caused by the thrips.

The method consists of cutting off the trees at the level of the ground. This eliminates the dying back of the cut ends due to branch pruning, avoids the injury which might follow low temperatures, and destroys the food supply and breeding places of the cam-

phor thrips. Without a single exception all trees cut near the ground sent up shoots from the crown, and in no instance did these shoots originate near the cut end of the stump. It is the nature of the trees to sprout from the crown instead of from any other place on the body of the tree. After a year or more these sprouts became rather large and vigorous and showed practically no damage from thrips. (Pl. VI, B; fig. 7.)

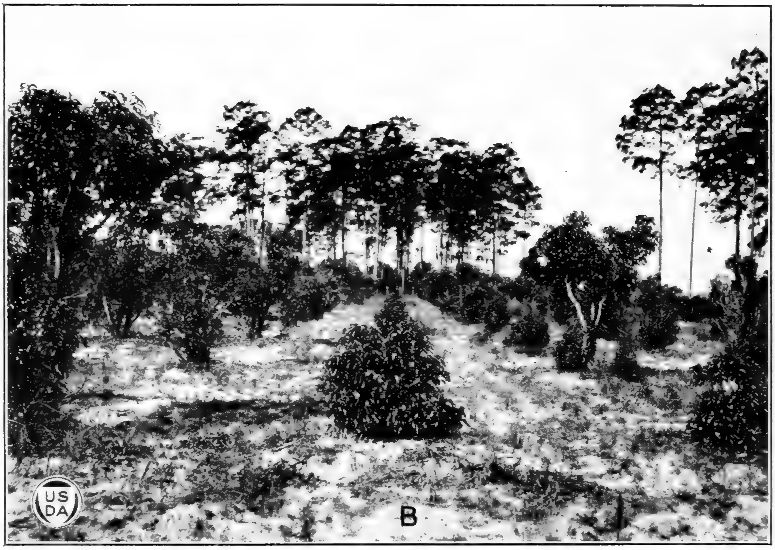
The camphor trees on a 60-acre tract at Satsuma were cut off at the level of the ground in November. The tops were not removed immediately, however, but were allowed to remain a few days after being cut down. This probably permitted some of the insects to reinfest the field. Neither were all of the small shoots growing near the base of the trees cut off, and they furnished a food supply for such insects as escaped from the cut tops. The work, however, was done on a

FIG. 7.—A field of camphor trees three months after being cut off at level of ground. The new growth originates at the crown and grows rapidly.

good commercial basis and no doubt was carried on as efficiently as could be expected. Repeated visits to this field showed that every tree sent forth sprouts from the crown and about a year afterward these were from 5 to 7 feet high. To be sure, some injury from thrips was noticed, but the damage was very slight. The greatest injury was on those trees located nearest the old unpruned trees across the road. The stumps were not treated with any material to prevent wood decay or kill thrips.

Pruning experiments were also conducted in a 10-acre field which had three sides not bordered by camphor trees. The trees in this field, also, were cut down at the level of the ground and all tops removed at once. All small shoots growing near the base of the stump were likewise carefully destroyed. In so far as was possible all sources of reinfestation from insects within the field were removed. Repeated visits to this field showed that all trees put forth sprouts from the crown and after the expiration of a year had attained a

OLDER LIMBS OF CAMPHOR TREES BADLY SCARRED AND DEFORMED AS A RESULT OF INJURY FROM THE CAMPHOR THRIPS.



EFFECTS OF DIFFERENT METHODS OF PRUNING CAMPHOR TREES.

A, field of camphor trees soon after being dehorned. This is an injurious system of pruning. *B*, two methods of pruning. The row in the center has been cut at the level of the ground and new growth has followed. The rows adjoining were improperly pruned and little new growth followed.

height of from 5 to 7 feet. They also appeared thrifty and vigorous. During the first three or four months after pruning no thrips were found nor any evidence of their presence. Very little damage was done to either the buds or branches during the first six months after pruning. After the expiration of more than a year there was some evidence of their presence, but the injury from them was so slight as to be of no importance whatever. Their presence in such small numbers has not interfered with the development of the trees in the least.

On this 10-acre block a great variety of tree-wound paints, varnishes, grafting waxes, and wood preservatives were used. None of these were of any value whatever in preventing reinfestation by thrips or in assisting the tree to produce more vigorous sprouts. In fact, the two rows treated with the wood preservative were injured to a considerable extent and did not send out shoots until several months after the untreated trees or those treated with other materials.

Additional experiments were conducted at Orlando to determine the effect of pruning at different times of the year on the growth of the trees and also to observe the relation of such pruning to the increase of the thrips. Thirteen rows of camphor trees averaging about 4 feet in height and planted in the form of a hedge were used for this experiment. One row was left unpruned for a check. Each month for a year, beginning in October and ending in September, one row was pruned. One-half of each of the pruned rows was cut on the level of the ground and one-half was cut exactly 1 foot high. Observations made throughout the year showed very plainly that those trees cut at the level of the ground during the winter months put forth much more vigorous and extensive growth than those cut the same way during the hot spring and summer months. The row of trees pruned during December seemed to have better growth than those cut during any other month of the year. At the end of a year all those trees pruned during the previous winter months had attained the same height that they were before being pruned to the ground and looked as well as the check row which was unpruned. The trees pruned during the summer did not attain the same height during that year but they came back in reasonably good shape also.

The half rows cut 1 foot from the ground gave results similar to those cut to the ground. The experiment showed that the winter months are unquestionably the best time to prune the trees. The trees pruned in the winter put forth much more vigorous growth and the growth came much sooner after the pruning than on those trees pruned during the summer. In this case the rows pruned during January and February were superior to those pruned during any other month. On the rows pruned during the hot summer months the sun scalded the exposed leaves and also killed the new shoots put forth from the cut ends. Hence there was little new growth until fall.

Although there was an abundance of thrips on the unpruned check throughout the year, except perhaps during March and April, no insects or injury were ever observed on the young growth on any of the trees cut at the level of the ground. The thrips, however, did much damage to the trees pruned 1 foot high. The injury was most severe on the half row pruned during the month of October, but there

was also considerable injury on the rows pruned in November and December. The least damage was noted on those trees pruned during the hot summer months. The thrips have a habit of congregating in large numbers along the sides of the stubs near the cut ends. They also lay large numbers of eggs on the cut surfaces. Hence these cut limbs are soon killed and are unable to put out new growth.

This experiment, like those previously recorded, showed that pruning the trees to the level of the ground results in much less injury from thrips and also produces a more vigorous growth then when the trees were pruned by the branch method.

TREATMENT OF ORNAMENTAL HEDGES.

When grown for ornamental hedges, it is often desirable to prune camphor trees frequently and thus keep the hedge in regular formation. Since this will result in injury from the pruning and also in subsequent injury by the thrips, some experiments were conducted on camphor hedges to determine whether they could be treated to prevent dying back and also to prevent much of the large infestation of thrips which usually follows pruning. A row of trees averaging about 4 feet in height were cut 1 foot from the ground on December 29. The cut ends of one-third of the row were treated with commercial or painter's shellac and one-third with concentrated lime-sulphur solution and nicotine sulphate containing 40 per cent nicotine, diluted 1 to 200. The remaining one-third of the row was left without any treatment whatever, as a check. As was to be expected, the thrips soon deposited enormous numbers of eggs on the cut ends of the untreated trees, but no eggs were deposited on the treated trees. The trees treated with shellac did not die back at all and after a few months put forth new growth near the cut ends. The shellac prevented the cut ends from drying out and consequently there were no unsightly dead branches. The lime-sulphur solution and nicotine sulphate treatment also prevented the trees from dying back to a large extent, but the growth started a little nearer the ground. The untreated trees also put forth vigorous growth, but the shoots were very close to the ground and unsightly dead branches were present in great abundance.

Therefore, if it is desirable to prune an ornamental hedge of camphor trees so that they will retain their beauty, it is advisable to treat all of the cut ends possible with some material that will seal them up and prevent their dying back and also prevent the thrips from ovipositing there. Shellac has proved to be the best material for this purpose.

FUMIGATION.

With the end in view of preventing the spread of camphor thrips on nursery stock and small camphor trees, some fumigation experiments were carried on to find a safe and effective method of treating the trees. Previous work along this line reported by Berger (*10*) and Newell (*7*) (*9*) showed that scrubbing and dipping the trees with soap, oils, and other insecticides is not entirely satisfactory. Many of the adults, larvæ, and pupæ can be destroyed in that way, but some of the eggs are so protected in the bark as to escape injury. The fumigation experiments were intended, therefore, to destroy the eggs in the bark lesions.

On October 20, 1921, four lots of 10 eggs each, deposited the same day, were fumigated with hydrocyanic-acid gas, two other lots being kept as checks. The four lots were placed in an airtight fumigatorium with a capacity of 25 cubic feet and subjected for two hours to a charge of gas produced from materials used at the strength of 1 ounce of sodium cyanid, 2 ounces of sulphuric acid, and 4 ounces of water to 100 cubic feet of space. After fumigation the limbs containing the eggs were removed and placed with the checks in the laboratory. The following day no effects could be noted on the eggs. On October 27, or seven days after treatment, the eggs were still unchanged and the check eggs were hatching. On October 28 all the checks had hatched. The experiment was discontinued October 31, since none of the fumigated eggs had hatched. No change in their appearance could be seen, but when broken they were found to contain a watery fluid, with no evidence of an embryo.

A similar experiment was performed on October 21, using 1 ounce of sodium cyanid and an exposure of one hour. The results were similar, no eggs having hatched up to October 31.

On November 1 another lot of eggs were fumigated, using one-half ounce of sodium cyanid to 100 cubic feet of space and an exposure of one hour. The checks all hatched on November 9 and 10. None of the treated eggs hatched, a few appearing shrunken and dried out after several days, but most of them remaining unchanged in appearance and containing a watery fluid. A final experiment was made on November 1, using two lots of eggs of about 40 each, which were fumigated for one hour at the rate of 1 ounce of sodium cyanid to 100 cubic feet of space. On November 7 a few of the eggs were shrunken and collapsed. By November 12 all the checks had hatched but none of the treated eggs hatched, nor did they contain any live embryos.

In all these experiments there was 100 per cent mortality of the eggs. Not a single egg remained alive after the fumigation. Results from the various dosages and exposures used did not differ appreciably. A strength of one-half ounce of sodium cyanid killed the eggs as well as stronger dosages. For commercial practice, however, it is recommended that the trees be exposed for one hour in an airtight fumigatorium to gas produced at a strength of 1 ounce of sodium cyanid to 100 cubic feet of space. The experiments prove that nursery stock can be entirely freed from the camphor thrips in all stages by this treatment.

Further experiments with living nursery stock showed that the trees will stand this treatment without any serious damage. On cut limbs the bark turned black after a few days and dried out sooner than it normally would, but on living camphor trees which were defoliated and well pruned back there was no apparent deleterious effect. In fact some of them withstood a dosage of 2 ounces of cyanid and an exposure of two hours.

Fumigation of course would not be practicable on commercial camphor plantations, nor would it be possible to use it on large ornamental trees and hedges. It is recommended only for nursery stock or small trees when removed from the ground for transplanting.

SUMMARY.

The camphor thrips first appeared in 1912 as an enemy to the newly developing camphor industry in Florida. At that time large acreages of camphor trees were being planted to produce a commercial supply of camphor gum. The tree was also being widely grown for its ornamental value, both individually and in hedges. The thrips appeared in enormous numbers when the trees were cut back to obtain wood for distillation, and also when ornamental hedges were pruned back in conventional shapes. The injury is not confined to pruned trees, but much more aggravated cases follow such treatment.

The thrips collect in large numbers on the stubs of the cut limbs and then attack the new shoots as soon as they appear. The buds are also attacked in the spring and at other times when new growth appears. By feeding on the buds and tender tips the insects cause them to become blackened and die back. Feeding also takes place along the limbs, with the result that the bark becomes blackened and cracks. Later these injured areas become enlarged by the thrips working down into the wood, even causing deformed limbs at times.

The camphor thrips probably is of Oriental origin, and not native to Florida, as was originally supposed. The bay trees of the genus Persea were believed for a time to be the native host of the pest, but the thrips which lives on the bay trees has been definitely shown to be a distinct species. Repeated efforts to rear and establish the camphor thrips on bay, avocado, and other closely related trees were unsuccessful. Its activities are confined entirely to camphor trees. The insect now occurs in practically all parts of Florida as well as in adjoining States where camphor trees grow. It reproduces rapidly, the generations requiring about 20 days in summer and 40 days in winter. The adults lay an average of 463 eggs and often live for several months.

The most practical method of control is a changed system of pruning the trees. Cutting the trees off at the surface of the ground rather than dehorning or cutting away part of the limbs eliminates most of the damage. This system removes all hibernating places of the thrips as well as their source of food. The trees later sprout out from the crown and the new growth resulting remains free from infestation for several months.

If done at the proper time, good control can be obtained by spraying with the following solution: ½ pound of 40 per cent nicotine sulphate, 2 quarts of potash fish-oil soap, and 2 quarts of lime-sulphur solution in 50 gallons of water. Since the thrips have the habit of hiding in the cracks and lesions of the bark during cool or cloudy weather it is recommended that spraying be done on a bright, sunshiny day. The maximum number of thrips will then be found feeding on the leaves and buds and other exposed places. This method of control will be found practicable only where a few trees are being grown for ornamental uses, since the cost would be prohibitive on a commercial camphor farm.

When it is desirable to cut back camphor hedges, a material such as shellac applied to the cut ends will prevent their dying back and will also prevent the thrips from ovipositing there.

Infested nursery stock can be fumigated with sodium cyanid at

the rate of 1 ounce to 100 cubic feet, with an exposure of one hour, with safety to the trees and absolute control of the thrips in all stages.

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